

the typhus dusting was restricted to cities and small towns, the reduction in cost was not significant.

**Spray Equipment** Since the beginning of the residual spray program, considerable controversy has developed on the question of hand equipment versus power equipment. Each State has adopted whatever type equipment appeared best for that particular area. Originally, power equipment consisted largely of orchard-type positive displacement power units. With the quality of hose available at that time, considerable trouble was experienced due to hoses breaking inside of houses, and this type of equipment soon fell into disrepute. During the 1947 spray season, the Tennessee program developed a pneumatic power spray unit. With reliable hose, satisfactory results have been experienced. Other States developed similar equipment which was used on certain portions of State programs during the 1948 spray season. At the beginning of the 1949 season, the North Carolina program had developed a standard unit (see illustration) for that State which consisted of the truck-engine-driven automatic air compressor, an air storage tank, a 70-90 gallon emulsion tank with two sets of spray hose, and necessary pressure regulators. This type of equipment was provided in all preapproved counties except one. A summary of seasonal activities indicates an increase of about 25 per-

cent in sprayman output over the 1948 season.

A constant-pressure hand-spray can, developed by the Technical Development Services, was field tested during the season. The unit consists of two concentric-drawn aluminum tubes welded at top and bottom; a constant-pressure regulator; and hose and wand assembly. From test results, it appears that the unit is practical, and negotiations are under way whereby similar units may be manufactured commercially.

### AUTOMOTIVE MAINTENANCE

One of the largest problems encountered in the residual spray program has been that of procurement, operation, and maintenance of automotive equipment. Procurement has been a headquarters problem, but operation and maintenance have been of local importance. Some States have relied on commercial facilities for maintenance and repairs, but most of them have set up shop facilities within the program and have succeeded in developing maintenance techniques with varying degrees of success. Two States in particular, Arkansas and Louisiana, inaugurated preventive maintenance practices during the 1949 season. As soon as the spray season is over, automotive units are brought to the State headquarters shop where they are completely overhauled and all exposed surfaces repainted or coated with a special rubberized paint preparation. The equipment is then stored at a central point.

## Results of the Residual DDT Spray Program Against MALARIA MOSQUITOES, 1945 - 1949

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The DDT Residual Spray Program for malaria control initiated in 1945 by State departments of health in the southeastern United States in cooperation with the Communicable Disease Center of the Public Health Service has completed 5 years of operational work, during which period

over five million house sprayings have been made. In 1949 the number of counties in which operations were carried on reached 344, and the number of individual houses treated was nearly one million.

The reduction of the malaria hazard by the

Residual Spray Program has been measured during the past 5 years in terms of its ability to maintain houses free of *Anopheles quadrimaculatus*. Control operations (in this country) have been directed specifically against those individual malaria mosquitoes which enter houses to bite and are therefore most likely to transmit malaria. The *A. quadrimaculatus* habit of resting and lingering within houses, especially after a blood meal, is well known; and it is this characteristic which results in control through the inside residual spraying of houses. Conclusions as to the effectiveness of the Residual Spray Program are based on data secured from inspections of randomly selected sprayed and unsprayed houses for the presence or absence of *A. quadrimaculatus*.

A 5-year summary of data is given in table 1 covering entomological evaluation of control operations on the Residual Spray Program for 13 southeastern States during the years 1945 through 1949. The data are based on a total of approximately sixty-five thousand inspections of sprayed and unsprayed houses. It should be noted that in 1945, the first year of the program, only sprayed houses were inspected, together with natural resting places such as barns and privies; and inspections of unsprayed houses for comparative purposes were not made until 1946. In 1945 two seasonal applications of DDT were applied at the rate of 100 milligrams per square foot. However, evaluation data indicated that a single seasonal application of 200 milligrams per square foot would be about equally effective from the standpoint of long-lasting residual and at the same time would be operationally more economical. Consequently, in subsequent years, 1946 through 1949, the 200 milligram application rate has been recommended and used in nearly all States.

It may be observed in table 1 that the average percentage of sprayed houses maintained free of *A. quadrimaculatus* for the 5-year period, 1945-1949, was 98.3 as compared to only 83.6 for unsprayed houses. Thus, the indicated over-all control (reduction in houses infested) was approximately 90 percent for the 5-year period. The gradual decrease in effectiveness of the residual during the course of the season is indicated by the average percentage of houses free of *A. quadrimaculatus* for each successive month

following the spray application. During the first month after spraying 99.1 percent of sprayed houses were free from *A. quadrimaculatus*; during the second month only 98.7 percent; in the third month 98.1 percent; for the fourth month 97.8 percent; and for the fifth month 96.5 percent. The indicated percentages of control, for successive periods of 0-1, 1-2, 2-3, 3-4, and 4-5 months after spraying were 95, 92, 88, 87, and 79 percent, respectively. Thus, it seems apparent that only a relatively gradual decrease in effective control occurs during the first 4 months after application, but thereafter the decline in effectiveness is accelerated.

Table 2 presents a summary of data on evaluation of the program for the years 1946 through 1949, showing for each year the ratio of the number of sprayed and unsprayed houses in which *A. quadrimaculatus* were found to the total number of sprayed and unsprayed houses inspected, and the indicated percentages of control obtained for the several years. The reason for omitting the year 1945 has already been given.

A comparison of the percentages of sprayed houses maintained free of *A. quadrimaculatus* for the years 1946 through 1949 (table 2) shows that there is a small but significant difference from year to year in these figures. A more marked degree of variation is seen in the comparable percentages for unsprayed houses. Two points appear worthy of emphasis here. One is that the variation from year to year between the percentages of unsprayed houses free from mosquitoes is believed to reflect the annual variations which occur in mosquito abundance from year to year in the southeastern States. In other words, it is indicated that the mosquito crop in 1947, when only 72.0 percent of the unsprayed houses were free of *A. quadrimaculatus*, was considerably larger, for example, than in 1949, when this percentage was 91.4. The other point is that the small but significant variation in the percentages of sprayed houses which were free from mosquitoes indicates the relatively consistent high level of control being achieved by the application of residual DDT spray. That this is true may be further illustrated by examining the indicated percentages of control achieved in the different years; namely, 92.1 percent in 1946; 95.7 percent

Table 1

Five-Year Summary of Entomological Evaluation of Residual Spray Program in 13 Southeastern States, 1945-1949, Based on 64,355 Inspections of Sprayed and Unsprayed Houses. Reduction in Malaria Hazard through Residual DDT Spraying Is Indicated by Comparison of Percentages of Inspected Houses Found Free of "Anopheles quadrimaculatus" in the Afternoon.

SPRAYED HOUSES																		
Months After Spraying	Number of Houses Inspected						Number of Houses with "A. quad." in p.m.						Percentage of Houses Free of "A. quad." in p.m.					
	1945	1946	1947	1948	1949	Total	1945	1946	1947	1948	1949	Total	1945	1946	1947	1948	1949	Average 1945-1949
0-1	3,916	6,018	1,546	699	1,064	13,243	42	49	12	22	5	130	98.9	99.2	99.2	96.9	99.5	99.1
1-2	4,558	6,739	2,690	1,354	1,871	17,212	79	66	40	24	15	224	98.3	99.0	98.5	98.2	99.2	98.7
2-3	3,557	5,321	2,538	2,093	2,304	15,813	154	50	32	36	28	300	95.7	99.1	98.7	98.2	98.8	98.1
3-4	1,375	2,974	1,578	2,102	1,530	9,559	73	39	20	57	22	211	94.7	98.7	98.7	97.3	98.6	97.8
4-5	723	899	442	1,231	404	3,699	42	16	5	67	2	132	94.2	98.2	98.9	94.6	99.5	96.5
All	14,129	21,951	8,794	7,479	7,173	59,526	390	220	109	206	72	997	97.2	99.0	98.8	97.2	99.0	98.3
UNSPRAYED HOUSES																		
	Number of Houses Inspected						Number of Houses with "A. quad." in p.m.						Percentage of Houses Free of "A. quad." in p.m.					
	1945	1946	1947	1948	1949	Total	1945	1946	1947	1948	1949	Total	1945	1946	1947	1948	1949	Average 1946-1949
	-	1,639	1,170	1,021	999	4,829	-	208	328	170	85	791	-	87.3	72.0	83.3	91.4	83.6

Table 2  
Summary of Entomological Evaluation of Residual Spray Program, 1946-1949.

	1946	1947	1948	1949	Average 1946-49
<b>SPRAYED</b>					
(1) Ratio of: No. Houses with <i>A. quadrimaculatus</i> to No. Houses Inspected	1:100	1:80	1:36	1:100	1:75
(2) Percentage of Houses Free of <i>A. quadrimaculatus</i>	99.0	98.8	97.2	99.0	98.7
<b>UNSPRAYED</b>					
(3) Ratio of: No. Houses with <i>A. quadrimaculatus</i> to No. Houses Inspected	1:8	1:4	1:6	1:12	1:6
(4) Percentage of Houses Free of <i>A. quadrimaculatus</i>	87.3	72.0	83.3	91.4	83.6
(5) Indicated Percentage of Control	92.1	95.7	83.2	88.4	92.0

in 1947; 83.2 percent in 1948; and 88.4 percent in 1949; and by the over-all average for this 4-year period of 92.0 percent control. These calculated percentages of control take into consideration the relative difference in mosquito abundance for the different years and they seem to demonstrate, other factors being equal, that effective control may be realized irrespective of seasonal variations in mosquito abundance.

Another way of showing, possibly a little more clearly, the magnitude of variation in annual malaria mosquito populations from year to year is by comparing the annual ratios of the number of unsprayed houses inspected in which mosquitoes were found to the total number of unsprayed houses inspected (table 2). These ratios are as follows: 1949, 1:12; 1948, 1:6; 1947, 1:4; and 1946, 1:8. Thus, in the year 1947, when mosquitoes are considered to have been most abundant, they were found in one house of every 4 inspected while in the year 1949, when mosquitoes were much less numerous, only one house out of every 12 inspected harbored mosquitoes. Similarly determined ratios for sprayed houses for these same years are worthy of note because they show by comparison the high degree of control realized on the Residual Spray Program. These ratios are as follows: 1949, 1:100; 1948, 1:36;

1947, 1:80; and 1946, 1:100. The ratio of 1:36 for the year 1948 appears to be a radical departure from the ratios for the other 3 years and is of especial interest to us from an evaluation of control standpoint. The calculated percentage of control realized in 1948 was only 83.2 as compared with the average percentage of 92.0 for the 4-year period, 1946-1949, or the average percentage of 93.9 for the 3 years 1949, 1947, and 1946. This reduction in effective control during 1948 quite possibly is accounted for by the fact that in this year a certain amount of difficulty was experienced through the use of substandard spray formulations in some areas. That this is a plausible explanation is supported by the fact that in each of the years 1947 and 1949 a much higher degree of mosquito control was obtained. It also is worthy of note that in the former year, 1947, mosquito populations were at the highest of any year during the period being reported.

Assuming that the entomological data presented here are a comparable measure of mosquito densities from year to year, it appears that annual differences in the percentages of control (table 2) were of statistical significance and that control operations were most effective in 1947, with 1946 ranking second, 1949 third, and 1948 in the lowest position.